PCT/GB 2004 / 0 0 3 2 2 4

The Patent Office

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

REC'D 27 AUG 2004
WIPO PCT

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed Andrew Gersey

Dated 16 August 2004

Patents Form 1/77

Patents Act 1977
(Rule 16)

26FEB04 E876161-3 D00027
P01/7700 0.00-0404202.4 NONE

THE PATENT OFFICE
25 FEB 2004
LONDON

1/77

The Patent Office
Cardiff Road
Newport
South Wales
NP10 8QQ

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1.	**Your reference**	74.66.81304/001
2.	**Patent application number** *(The Patent Office will fill in this part)*	0404202.4 — 25 FEB 2004
3.	**Full name, address and postcode of the or of each applicant** *(underline all surnames)*	4Cyte Limited The Tyrrell Building Long Reach Ockham Surrey GU23 6PG United Kingdom
	Patents ADP number *(if you know it)*	8151615001
	If the applicant is a corporate body, give country/state of its incorporation	United Kingdom
4.	**Title of the invention**	A Method and Apparatus for Forming a Moulding
5.	**Name of your agent** *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001

		Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6.	**Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months**	GB	0317508.0	25/07/2003

		Number of earlier UK application	Date of filing *(day / month / year)*
7.	**Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute** *(see note f)*		

8. **Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request?**

Answer YES if:
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
Otherwise answer NO (See note d)

Yes

9. ccompanying documents: A patent application must include a description of the invention.
Not counting duplicates, please enter the number of pages of each item accompanying this form:

Continuation sheets of this form	0
Description	22
Claim(s)	0
Abstract	0
Drawing(s)	6 +6

10. If you are also filing any of the following, state how many against each item.

Priority documents	0
Translations of priority documents	0
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	0
Request for a preliminary examination and search *(Patents Form 9/77)*	0
Request for a substantive examination *(Patents Form 10/77)*	0
Any other documents *(please specify)*	No

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 25 February 2004

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom

David Leckey
01273 244200

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*
b) *Write your answers in capital letters using black ink or you may type them.*
c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s) of the form. Any continuation sheet should be attached to this form.*
d) *If you have answered 'Yes', Patents Form 7/77 will need to be filed.*
e) *Once you have filled in the form you must remember to sign and date it.*
f) *Part 7 should only be completed when a divisional application is being made under section 15(4), or when an application is being made under section 8(3), 12(6) or 37(4) following an entitlement dispute. By completing part 7, you are requesting that this application takes the same filing date as an earlier UK application. If you want the new application to have the same priority date(s) as the earlier UK application, you should also complete part 6 with the priority details.*

DUPLICATE

81304.209

A METHOD AND APPARATUS FOR FORMING A MOULDING

The invention relates to a method and apparatus for forming a moulding, more particularly an injection moulding.

Injection moulding is a technique in which a moulding material is injected into a mould such that it coats the mould surfaces. The moulded component may then be allowed to harden prior to removal from the mould.

However, a significant disadvantage of injection moulding is that the flow of the moulding material within the mould, and hence the finished appearance of the moulding, is highly dependent upon the shape of the mould. Moulds having simple, continuous surfaces generally produce mouldings having a surface of a reasonably consistent appearance. However, moulds having irregularly shaped or discontinuous surfaces distort the flow of the moulding material within the mould and hence result in the product having a surface appearance which is non-uniform or distorted. For example, a mould formed with regions for producing a moulding having holes or protrusions therein may cause non-uniform flow lines in the moulding about these regions. This typically results in the moulding having a distorted appearance. The surface appearance of the moulding is further distorted by weld lines produced about the interface between the components of the mould.

Furthermore, because the moulding material is injected into the mould it is not possible to produce an

image on the moulding surface or vary the appearance over the surface.

Dual injection moulding is a specific type of injection moulding in which a first material is injected into a mould followed by a second material. The first material coats the mould surfaces, while the second material forms a substrate for the first material. The composite moulded component may harden in the mould prior to removal from the mould.

Dual injection moulding processes may be used to provide a paint coating on a moulded plastics body. In such a process paint is injected as the first material and the base plastic as the second material. Such a process has the advantage that the moulding is co-formed with a paint coating and thus does not need subsequent painting.

An example of a dual injection moulding process which produces a pre-painted moulding is disclosed in GB 2280401. This document discloses a method of forming a painted moulding wherein a powdered or granulated plastics paint material is heated and injected into a mould, followed by the injection of a substrate plastic. The use of powdered or granulated plastics enables a more controllable flow to be obtained in the mould resulting in a paint coating thickness which is more uniform.

However, as with the injection moulding techniques discussed above, wherein a single material is injected into the mould, the surface appearance of a product produced by dual injection moulding is also affected by weld lines and is highly dependent upon the profile of the inner surface of the mould. Moulds having irregular or discontinuous inner surfaces cause the flow of the

first coating (i.e. paint coating) across the surface of the mould to be distorted. This results in the first outer coating of the moulding having a distorted appearance.

This is particularly visible when the moulding requires a metallic paint finish, because the reflective, metallic flakes used in the first coating material align with the flow lines of the coating material. Furthermore, because the paint layer is injected into the mould it is not possible to produce an image on the moulding surface or control the surface appearance of the moulding.

Accordingly, it is an object of the present invention to provide an improved method and apparatus for forming a moulding by an injection moulding process, wherein the moulding has an appearance which is not distorted by weld lines or by the flow lines of the coating material.

A further object of the present invention is to provide a method and apparatus for forming a moulding by injection moulding wherein the moulding has a predetermined image, pattern or texture thereon.

From a first aspect there is provided a method of forming a moulding by injection moulding. The method comprises injecting a moulding material into a mould, the moulding material comprising magnetic particles. The method further comprises applying a magnetic field to at least a portion of the moulding material so as to change the orientation and/or distribution of magnetic particles in the moulding material.

From a second aspect there is provided a moulding apparatus comprising a mould and means for injecting a moulding material into the mould, wherein the moulding

material comprises magnetic particles. The apparatus further comprises means for applying a magnetic field in the mould so as to change the orientation and/or distribution of magnetic particles in the moulding material.

From a third aspect there is provided a method of forming a moulding by multiple injection moulding. The method comprises injecting a first material into a mould, injecting at least a second material into the mould behind the first material so that the first material covers a surface of the mould, wherein at least one of the materials includes magnetic particles. The method further comprises applying a magnetic field to at least a portion of at least one of the materials so as to change the orientation and/or distribution of magnetic particles in at least one of the materials.

From a fourth aspect there is provided a moulding apparatus comprising a mould, means for injecting a first material into the mould and means for injecting at least a second material into the mould, wherein at least one of the materials comprises magnetic particles. The apparatus further comprises a means for applying a magnetic field in the mould so as to change the orientation and/or distribution of magnetic particles in at least one of the materials.

In a preferred embodiment, the first material comprises a coating material which coats the moulding and the second material comprises a substrate material. Preferably, the coating material comprises the magnetic particles.

In another preferred embodiment, at least a third material is injected into the mould after the second material is injected. In this embodiment, preferably

the first material forms a coating layer, the second material comprises magnetic particles and the third material forms a substrate layer.

It is further contemplated that fourth, fifth, sixth, seventh or a higher number of materials may also be injected into the mould, each of which may or may not comprise magnetic particles.

Thus in accordance with the invention, at least one material is used which contains magnetic particles, and a magnetic field is applied to the material(s) in the mould so as to cause a desired orientation and/or distribution of the magnetic particles in the material(s) to give a desired visual effect. By choice of appropriate magnetic fields it is possible to compensate for the irregular surface appearance which may be caused by weld lines or non-uniform flow lines within the moulding. Furthermore, the magnetic field(s) may also be such as to form a desired image, pattern or texture in the material(s) comprising magnetic particles.

More particularly, the concentration and/or orientation of the magnetic particles within a given region of the moulding will determine the appearance of the moulding surface. These properties may be manipulated and controlled by the magnetic field(s) so as to produce any desired surface appearance. The magnetic particles align along the magnetic field(s) which are applied to the coating. Thus, in a preferred embodiment, for example, the level of light reflection and/or absorption by the magnetic particles in a particular region may be altered by changing the orientation and/or concentration of the particles in that region. For example, the magnetic fields may be

arranged to move the magnetic particles into or from a particular region of the moulding or may change the orientation of the magnetic particles such that light is incident on a larger area of the particles to increase the reflectivity or absorption of that region of the moulding.

In moulds having irregular or discontinuous surfaces such as holes, protrusions or the interfaces between the multiple mould components the present invention can be employed to compensate for the distorted appearance created at these regions. The magnetic fields may be arranged such that the magnetic particles are drawn to give a substantially uniform coating and/or be orientated in the required direction. Any desired image may also be formed on the moulding surface, or substrate surface in multiple injection moulding, by arranging the magnetic fields to draw or push relatively reflective or absorptive magnetic particles to or from regions of the moulding. In this manner two-dimensional, three-dimensional and/or textured appearances may be created in regions of the moulding during the moulding process.

In the preferred embodiment the mould surface may be heated electrically, or by any other means, in order to prevent the moulding surface from curing or "skinning" before the magnetic particles have been manipulated as desired.

The magnetic particles which are included in the moulding or coating and/or substrate material may consist of a magnetic core which may be spherical, elongated or any other shape. Preferably, the magnetic core is elongated and coated with an outer layer

consisting of a material which reflects or absorbs light relatively well.

In a preferred embodiment the magnetic particles are nickel. In some embodiments the particles may comprise a nickel core which may be coated in, for example, aluminium or alternatively coated with, for example, magnesium fluoride and aluminium or another metal. The magnetic particles may also have coloured coatings.

In a preferred embodiment the magnetic particles comprise leafing grade nickel flakes such as those manufactured by Novamet Speciality Products Corporation. Such flakes may be used in a coated or uncoated state. More preferably, extra fine pigment grade nickel flakes are used in the moulding or coating and/or substrate materials. The magnetic particles can be added to the moulding or coating and/or substrate materials as a dry powder or pigment slurry.

In certain embodiments, for example when a single moulding material is injected into the mould, the magnetic particles may make up 2-15% of the weight of the material(s) comprising magnetic particles. More preferably, the magnetic particles comprise 3-10% of the material(s) by weight. Even more preferably, the magnetic particles make up 5% of the material(s) by weight. In other embodiments, for example when more than one material is injected into the mould, the magnetic particles may make up 0.1-15% of the weight of the material(s) comprising magnetic particles. More preferably, the magnetic particles comprise 0.5-10% of the material(s) by weight. More preferably, the magnetic particles comprise 0.1-3% of the material(s) by weight. Even more preferably, the magnetic particles

make up 2% of the material(s) by weight. However, it is also contemplated that the magnetic particles can be added to the material(s) in any desired proportion and the magnetic particles may make up more than 15% or less than 0.1% of the weight of the material(s). In a preferred embodiment, the substrate and coating materials of the moulding comprise different weight percentages of magnetic particles.

Where the particles are being added to a moulding material, rather than a coating, it is preferred that the moulding material is transparent. Pigment may be added to the material for decorative effect

The magnetic fields which manipulate the magnetic particles may be generated by one or more permanent magnet and/or electromagnets provided in or adjacent the mould.

The poles of the magnets may be arranged such that the magnetic fields are substantially parallel, perpendicular or oblique to the surface of the region of the mould comprising the magnetic particles which are to be manipulated.

These magnets may be recessed into or formed integrally with the inner or outer surfaces of the mould, or disposed between the inner and outer surfaces. Alternatively, the magnets may be arranged adjacent to the surfaces of the mould.

In some embodiments an electromagnet is used, particularly when it is desired that the magnetic field is applied only selectively during the moulding process.

Any number of magnets having any shape or size may be used in the apparatus depending upon the desired pattern or effect to be achieved. The strength of the magnetic field and the duration that it is applied may

also be varied depending upon the effect to be achieved, the distance and material between the magnet and material comprising magnetic particles and the level of curing of the material comprising magnetic particles.

In order to vary the strength or position of the magnetic fields the magnetic field generating means may be movable relative to the mould. In such an embodiment magnets may be positioned, for example, within bores in the mould casing and may move perpendicularly or parallel to the coating. Alternatively, if electromagnets are employed, the power delivered to them may be varied.

In the preferred embodiment, the mould is made from metal, preferably steel. Magnets may be provided in regions of the mould by drilling a bore part way or completely through the mould. The bore may then be plugged with a non-magnetic material. Once the bore has been plugged with the non-magnetic material it may then be drilled itself to provide a bore for inserting a magnetic material. After the magnetic material has been inserted into the bore the edges of the mould, non-magnetic and magnetic materials are preferably peened over and the whole region polished smooth.

From a further broad aspect the invention provides a mould for injection moulding plastics, the mould having one or more openings receiving a copper insert, the copper insert comprising a magnetic insert.

In a preferred embodiment, the bore drilled into the mould is cylindrical and may have a diameter of approximately 5 mm. This bore may then be filled with non-magnetic copper which is then preferably bored into to provide a cylindrical bore of diameter 2 mm for receiving the magnetic material. Preferably, the

magnetic material is a sintered ferrite magnet. In the preferred embodiment, the non-magnetic material is provided between the magnetic material and the mould inner surface in order to substantially prevent the inner surface of the mould from becoming magnetised as this may adversely affect the orientation and/or distribution of the magnetic particles in the moulding. In a less preferred embodiment the mould itself may be manufactured from a non-magnetic material, such as non-magnetic steel, which may be bored into in order to insert the magnetic material directly.

In the preferred embodiment liquid, powdered or granulated material may be used as the moulding, coating and/or substrate material which includes the magnetic particles.

Where the magnetic particles are being added to a moulding material (rather than to a coating), it is preferred that the moulding material is transparent or translucent. Tints may be added to the plastics material to give a desired colour.

The moulding, coating and/or substrate material is preferably heated to a plastic condition and injected into the mould. It is particularly preferred to use a powdered or granulated plastics material of a thermosetting kind which has a thermoplastic phase, with the magnetic pigment mixed therewith. In such a case the powdered or granulated plastics material can be heated sufficiently to bring it to a plastic condition (typically a putty-like conditions) in its thermoplastic phase to enable it to be injected at high pressure into the mould (e.g. in excess of 1000 bar). For example, heating a powdered or granulated plastics material to a temperature in the range 80 °C to 260 °C will normally

bring it to a plastic condition for injection into the mould. With such a material, the heat absorbed to bring it to the plastic phase may ideally be utilised to cause the material to begin thermosetting, e.g. as it coats the mould or, in multiple injection moulding, following the introduction of the substrate material. In that way reasonably rapid curing of the mould can be achieved. However, if desired, the coating can be cured or curing can be completed after removal of the moulding from the mould, i.e. post-cured.

Post curing enables the curing temperature and curing time to be particularly carefully controlled. This is particularly advantageous in multiple injection moulding with regard to creating a strong bond between the coating and substrate materials.

In dual or multiple injection moulding the coating and substrate materials are preferably selected so as to have an affinity for one another. Cross-linking between the moulded coating and substrate materials may be effected during moulding or curing of the material.

The method and apparatus provided in accordance with the present invention are particularly suited to the production of casings for electronic equipment and various body components of a motor vehicle.

Various embodiments of the present invention will now be described, by way of example only, and with reference to the following drawings in which:

Fig. 1 is a diagrammatic cross-section through an injection moulding machine showing the injection into a mould of a moulding material comprising magnetic particles;

Fig. 2 is a diagrammatic cross-section through an injection moulding machine showing the form of the moulding after injection of the moulding material;

Fig. 3 is a diagrammatic view of the moulding removed from the mould and placed in an oven for post curing the coating;

Fig. 4 is a partial view of a cross-section through an injection moulding machine showing the alignment of the magnetic particles in the moulding material;

Fig. 5 is a diagrammatic cross-section through a dual injection moulding machine showing the injection into a mould of coating material comprising magnetic particles;

Fig. 6 is a diagrammatic cross-section through a dual injection moulding machine showing the injection into a mould of substrate material;

Fig. 7 is a diagrammatic cross-section through a dual injection moulding machine showing the form of the moulding after injection of the substrate material;

Fig. 8 is a diagrammatic cross-section through a dual injection moulding machine showing another injection of the coating material to coat the substrate at the region of the injection port;

Fig. 9 is a diagrammatic view of the moulding removed from the mould and placed in an oven for post curing the coating;

Fig. 10 is a cross-section to a larger scale through part of a component made by a method in accordance with the preferred embodiment;

Fig. 11 is a partial view of a cross-section through a dual injection moulding machine showing the alignment of the magnetic particles in the coating material; and

Fig. 12 is a partial view of a cross-section through a multiple injection moulding machine into which three materials have been injected.

With reference to Fig. 1, an injection moulding machine has a mould 10 having first 12 and second 13 halves defining a hollow cavity 14 therebetween. The hollow cavity 14 communicates with a block 15 which defines a passageway 16 for material from extruder 17. A rotary valve 20 may be positioned between the block 15 and an inlet port 22 in mould half 13 to selectively allow moulding material 23 to be injected into the cavity 14. A number of permanent magnets 21 may be arranged within the mould halves 12,13 in any desired position.

The extruder 17 may be associated with a heater 17a and is operated to deliver the moulding material 23 comprising magnetic particles. The moulding material 23 may consist of liquid paint although is preferably formed by heating thermosetting granulated plastics paint material 23a, including the magnetic particles, into a thermoplastic phase in which it takes on a putty-like plastic condition. A suitable granulated plastics material has been found to be one which will have a plastic condition at a temperature of around 170 °C with a putty-like viscosity. Preferably, the moulding material 23 comprises a substantially transparent or translucent plastic such as polycarbonate provided in the form of granules. The plastic may be mixed with magnetic particles comprising nickel flake pigment at a ratio of 3% by weight before being heated and injected into the mould 10 at a temperature of approximately 280 °C. In a preferred embodiment the plastic material may be tinted with any colour, for example, by use of

plastic tints. In this embodiment the cycle time between shots may be approximately 20 seconds.

The magnets 21 produce a magnetic field within the mould 10. The magnets 21 are arranged such that the fields manipulate the magnetic particles in the moulding material 23 before it has cured. The magnetic fields may be arranged to distribute and/or re-orientate the magnetic particles such that the moulding has a uniform appearance, or alternatively, to produce a moulding of which at least a portion is created having a 2-D, 3-D or textured image or appearance.

The moulding material 23 is preferably injected into the cavity 14 whilst the mould 10 is at an elevated temperature. The temperature of the mould may be in a range of, for example, 20 °C to 150 °C, preferably around 100 °C. The valve 20 may then rotated to shut off the feed of moulding material 23.

The heat applied to the thermosetting moulding material 23 while it is temporarily in the extruder 17 is absorbed by the material 23 and, once in the mould 10, the heat will begin the curing process of the material 23. That process may begin as the material 23 is being spread over the mould 10 surfaces or may begin after the injection steps are complete. However, the magnetic fields are applied to manipulate the magnetic particles in the moulding material 23 before the curing process is completed. Preferably, the inner surface of the mould 10 is maintained at an elevated temperature of, for example, 100 °C in order to prevent the outer surface of the moulding from completely curing or "skinning" before the magnetic particles have been manipulated as required.

Fig. 2 shows a cross section through the injection moulding machine showing the form of the moulding after injection of the moulding material 23.

Referring to Fig. 3, the moulding 11 can be removed from the mould 10 and placed in an oven 30 to further heat and cure the moulding material 23. The oven is pre-heated to a temperature of, for example, around 250 °C. The moulding 11 may be subjected to heat at that temperature as indicated by arrows for a period which is sufficient to cure the moulding material 23 but which is insufficient to have a significant softening effect on the structure of the moulding 11. Further magnetic fields may be applied to the moulding 11 at this stage if desired.

Fig. 4 shows a portion of a cross-section through the injection moulding machine. In this embodiment elongated magnetic flakes 40 have been added to the moulding material 23. It has been found that as the moulding material 23 spreads over the surfaces 14a of mould cavity 14, the spreading or flowing action causes the magnetic flakes 40 to orientate themselves so that they lie generally in a plane parallel with the flow. It can be seen that in this embodiment the magnetic fields have been arranged to orientate the magnetic flakes 40 in substantially the same direction and concentration throughout the outer portion of the moulding such that a moulding having a uniform appearance will be produced, regardless of the direction of the flow lines. In addition the magnetic fields may orientate the magnetic flakes 40 to lie so as not to project from the surface of the finished moulding.

Fig. 5 depicts a schematic of a dual injection moulding machine. The moulding machine has a mould 10

having first 12 and second 13 halves defining a hollow cavity 14 therebetween. The hollow cavity 14 communicates with a block 15 which defines a passageway 16 for material from a first extruder 17 and a second passageway 18 for material from a second extruder 19. A rotary valve 20 is positioned between the block 15 and an inlet port 22 in mould half 13 for selection of the material to be injected into the cavity 14. A number of permanent magnets 21 may be arranged within the mould halves 12,13 in a desired position.

The first extruder 17 is associated with a heater 17a and is operated to deliver a coating material 23' which may comprise magnetic particles. The coating material may consist of liquid paint or may be formed by heating thermosetting granulated plastics paint material 23a' including magnetic particles into a thermoplastic phase in which it takes on a putty-like plastic condition. A suitable granulated plastics paint material has been found to be one which will have a plastic condition at a temperature of around 170 °C with a putty-like viscosity.

An initial quantity of the coating material 23' is injected into the cavity 14, the mould 10 being at a temperature in a range of, for example, 20 °C to 100 °C. The valve 20 is then rotated to shut off feed of coating material 23'.

Fig. 6 shows the step in which the substrate material 24 is injected. A thermoplastics substrate material 24, such as ABS or nylon 24a, is heated in a heater 19a associated with the second extruder 19 and is injected into the cavity 14 behind the injected coating material 23'. Injection of the substrate material 24 causes the coating material 23' to spread over the mould

surfaces 14a defining cavity 14 and injection is continued until the inner surfaces of the mould 10 are coated with the coating material 23', which also envelopes the substrate material 24. In addition to the coating material 23' or, less preferably, alternatively the substrate material 24 may comprise magnetic particles. In this embodiment the coating material 23' may be substantially transparent or translucent in order to allow the magnetic particles in the substrate material 24 to enhance or provide the desired visual effect.

Fig. 7 shows a cross-section of the moulding machine after injection of the coating material 23' and substrate material 24. It can be seen that the substrate material 24 forms a thermoplastic substrate or core having a coating or skin formed by the coating material 23'.

The magnets 21 produce a magnetic field within the mould 10. The magnets 21 are arranged such that the fields manipulate the magnetic particles in the fluid coating material 23' and/or substrate material 24 before it has cured. The magnetic fields may be arranged to distribute and/or re-orientate the magnetic particles such that the moulding has a uniform appearance, or alternatively, to produce a moulding of which at least a portion is created having a 2-D, 3-D or textured image or appearance.

In Fig. 8, the valve 20 has been rotated again to shut off feed from the extruder 19 and to again permit injection of coating material 23' into the port 22 so that the machine 10 is ready for another injection cycle. The coating material 23' is injected into the

mould 10 to coat the substrate material 24 in the region of the entrance port 22.

The heat applied to the thermosetting coating material 23' while it is temporarily in the extruder 17 is absorbed by the coating material 23' and, once in the mould 10, the heat will begin the curing process of the material 23' and substrate material 24. The curing process may begin as the coating material 23' is being spread over the mould 10 surfaces by the incoming substrate material 24 or may begin after the injection steps are complete. However, the magnetic fields are applied to manipulate the desired magnetic particles in the coating 23' and/or substrate 24 material before curing of the respective material(s) is completed.

Preferably, the curing of the thermosetting coating material 23' and substrate material 24 will also allow sufficient time to enable cross-linking to take place between the two materials 23',24 thereby ensuring an extremely good bond between them. Instead of a cross-linking occurring between the coating 23' and substrate 24 materials, a good bond alone may be achieved between them due to their intimate contact during injection.

Referring to Fig. 9, the moulding 11 can be removed from the mould 10 and placed in an oven 30 to further heat and cure the coating material 23'. The oven is pre-heated to a temperature of, for example, around 250 °C. The moulding 11 is preferably subjected to heat at that temperature as indicated by arrows for a period which is sufficient to cure the coating material 23' but which is insufficient to have a significant softening effect on the bulk of the thermoplastics substrate material 24. Further magnetic fields may be applied to the moulding 11 at this stage if desired. It is

believed that with careful control of timing and temperature, a good bond will be achieved between the coating material 23' and the substrate material 24.

The substrate material 24 is preferably selected so that it will have an affinity to the coating material 23' and materials such as ABS and nylon constitute suitable substrate materials 24 for such a coating material 23'.

Referring to Fig. 10, the depth d of the coating material 23' can be selected to be at least as thick as a paint coating which would normally be applied to, say, a car body component in a paint spraying or dipping facility. Also, the injection moulding tool 10 can provide a superfine surface finish for the coating material 23' which will compare well with that obtained by spray or dip painting.

Moreover, by producing a moulding 11 having a predetermined appearance in an injection moulding process, the finished moulding will be free from contamination by air-borne dust as well as being uniform and consistent. Also, the method of the preferred embodiment is cleaner and more environmentally friendly than producing a moulding having a finish using a conventional paint facility because the preferred process does not involve extracting contaminated air or effluent from a paint facility and emitting it into the atmosphere.

If desired, the substrate material 24 can be a thermosetting material instead of a thermoplastics material. The injection steps will be the same as that described above with reference to the drawings except that the mould 10 will be hotter, for example, at a temperature in a range 100 °C to 180 °C. As before, the

heat applied to the coating material 23' will lead to the onset of curing and the hot mould 10 will speed up curing of the coating formed by coating material 23'. The heat from the mould 10 may also at least partially cure the substrate material 24. If desired the moulding 11 can be left to cure completely in the mould 10 or can be removed for post curing outside the mould, for example, in an oven 30. In the latter case heat applied to the thermosetting substrate material 24 preferably does not present any distortion problems to the thermosetting material.

The substrate material 24 may be injected as a foamed thermoplastic/thermosetting material.

Fig. 11 shows a portion of a cross-section through the dual injection moulding machine. In this embodiment elongated magnetic flakes 40 have been added to the coating material 23'. It has been found that as the coating material 23' spreads over the surfaces 14a of mould cavity 14, the spreading or flowing action causes the magnetic flakes 40 to orientate themselves so that they lie generally in a plane parallel with the flow. It can be seen that in this embodiment the magnetic fields have been arranged to orientate the magnetic flakes 40 in substantially the same direction and concentration throughout the coating layer 23' such that a moulding having a uniform appearance will be produced, regardless of the direction of the flow lines. In addition the magnetic fields may orientate the flakes 40 to lie so as not to project from the finished surfaces of the moulding 11.

In another embodiment one or more further materials may be injected into the cavity 14.

Fig. 12 shows a cross-section through a multiple injection moulding machine into which three materials have been injected. A first material 23'' is injected into the cavity 14 followed by a second material 24'. Preferably, at least a third material 25 is then injected into the cavity 14. Preferably, the second material 24' comprises magnetic particles and may be injected into the cavity 14 before the first material 23'' has completely cured. In this manner the region of the second material 24' in contact with the coating layer 23'' is prevented from "skinning" during the injection process. As such, the boundary between the adjacent layers 23'',24' does not appear distorted and the magnetic particles are able to move over the inner surface of the first material 23'' during the injection process. Similarly, the third material 25 may be injected into the cavity 14 before the second material 24' has cured completely.

In this embodiment the first material is preferably a coating material 23'' and the third material 25 may be a substrate layer. The coating material 23'' may be relatively hard or resilient and/or translucent or transparent. The coating material 23'' may serve to protect the second material 24' which contains the magnetic particles. Further, as the layer 24' containing the magnetic particles is provided between the coating 23'' and substrate 25 materials it need not provide any structural function and therefore may have a relatively small volume. This relatively small volume is advantageous as it enables the quantity of magnetic particles required to achieve the desired visual effect.

Although the present invention has been described with reference to the preferred embodiments, it will be

understood by those skilled in the art that various changes in form and detail may be made without departing from the scope of the invention as set forth in the accompanying claims.

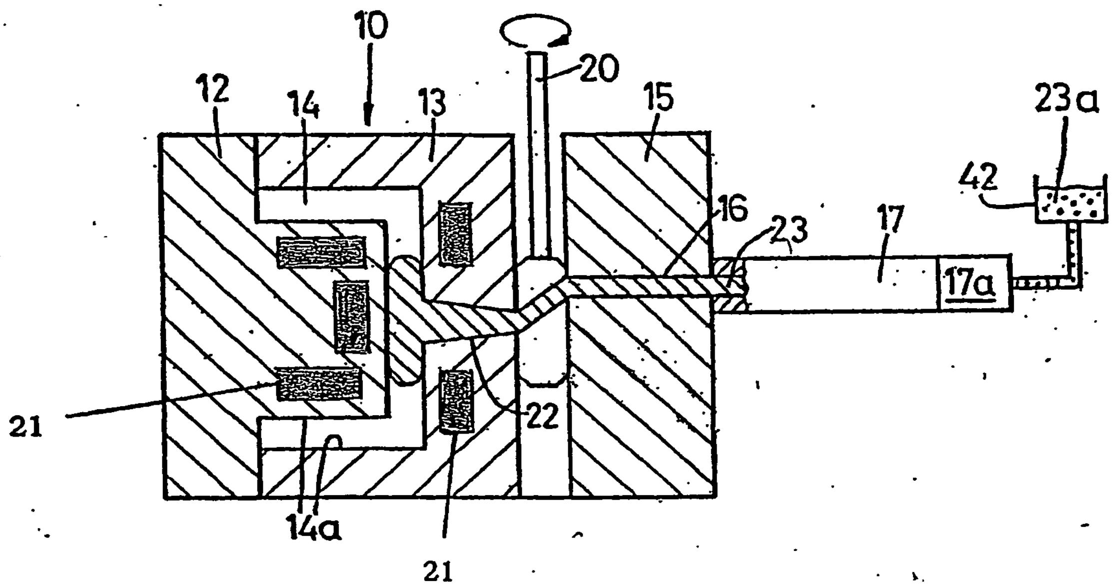
10
12
14
13
20
15
23a
42
16
23
17
17a
21
22
14a
21

Fig. 1

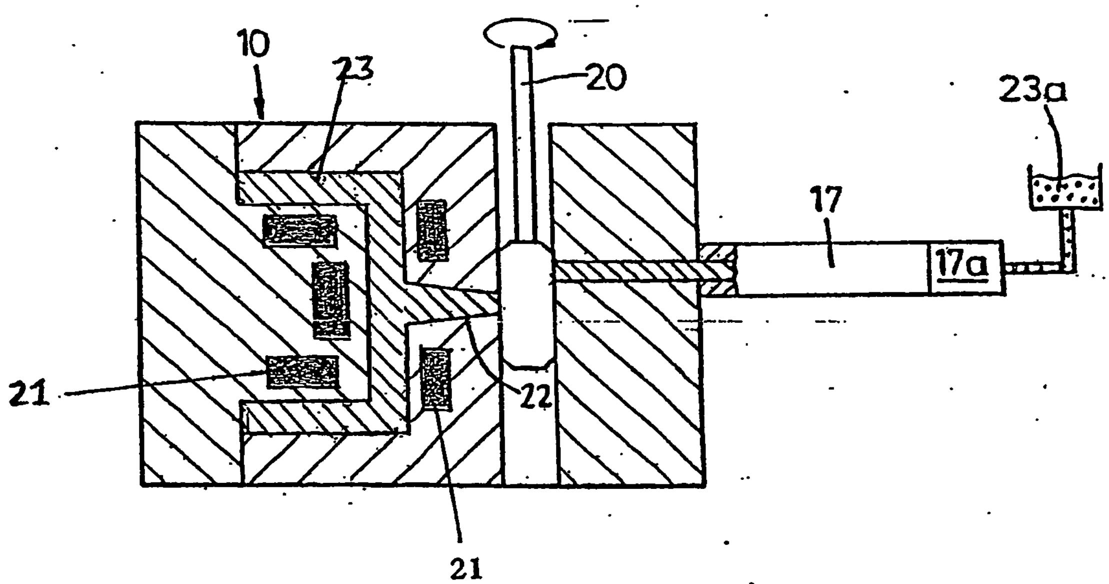
10
23
20
23a
17
17a
21
22
21

Fig. 2

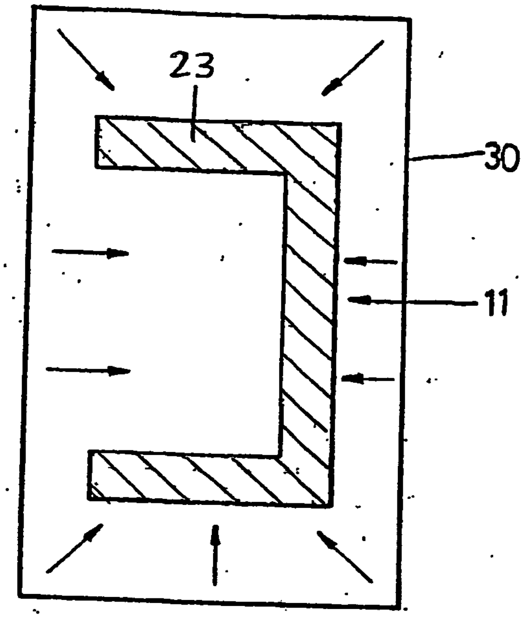

Fig. 3

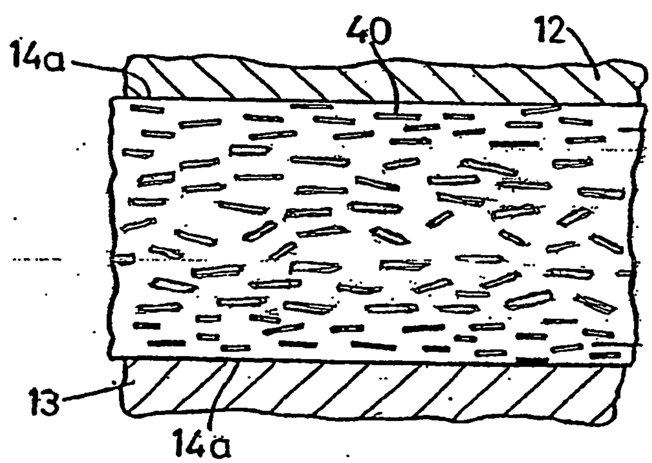

Fig. 4

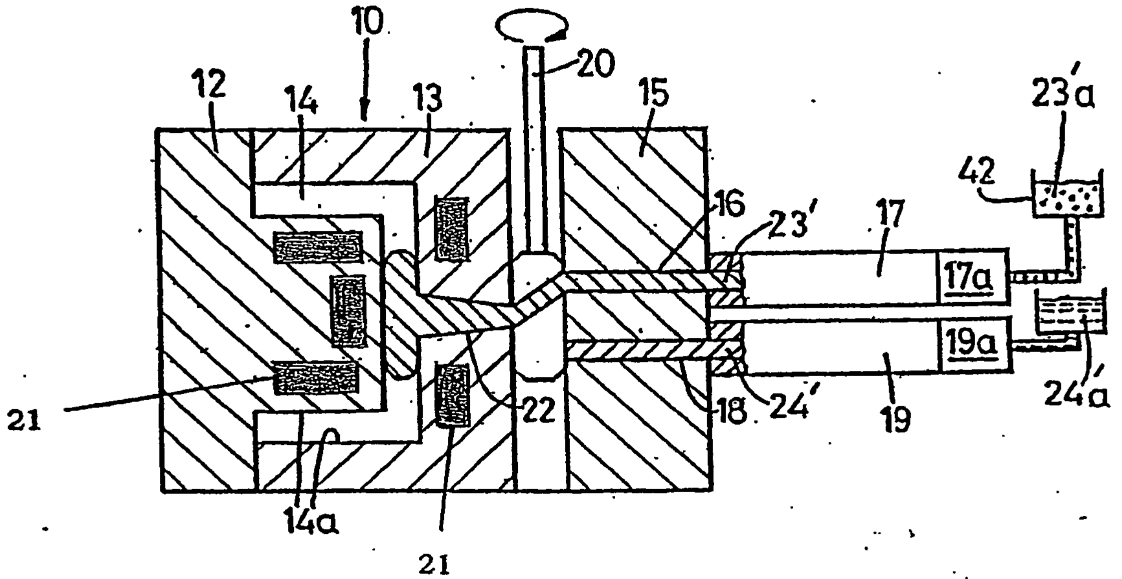
10
12
14
13
20
15
23'a
42
16
23'
17
17a
19a
24'a
21
22
18
24'
19
14a
21

Fig. 5

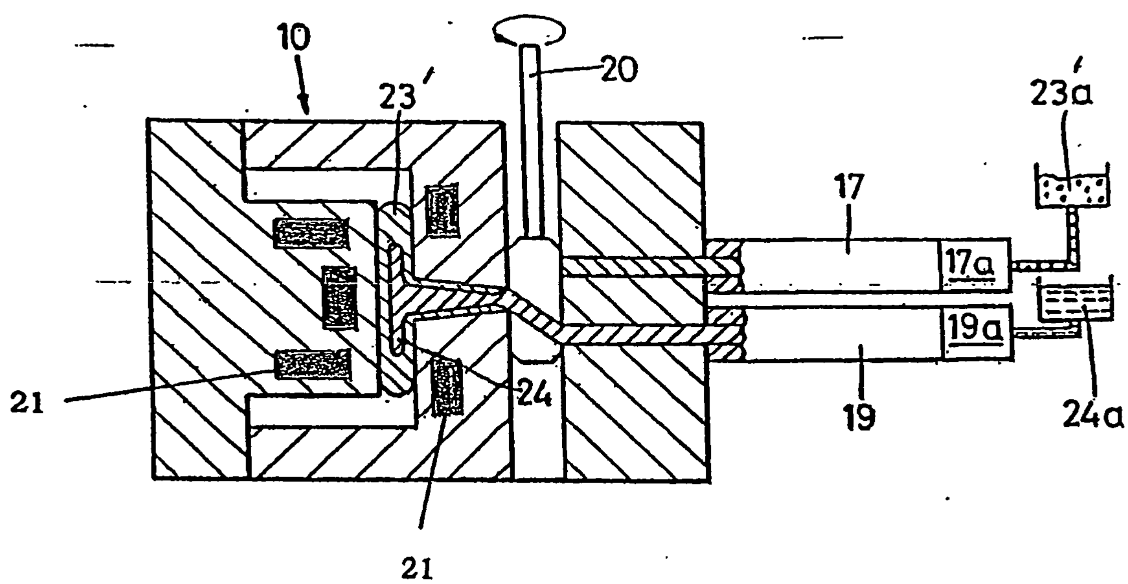
10
23'
20
23'a
17
17a
19a
21
24
19
24a
21

Fig. 6

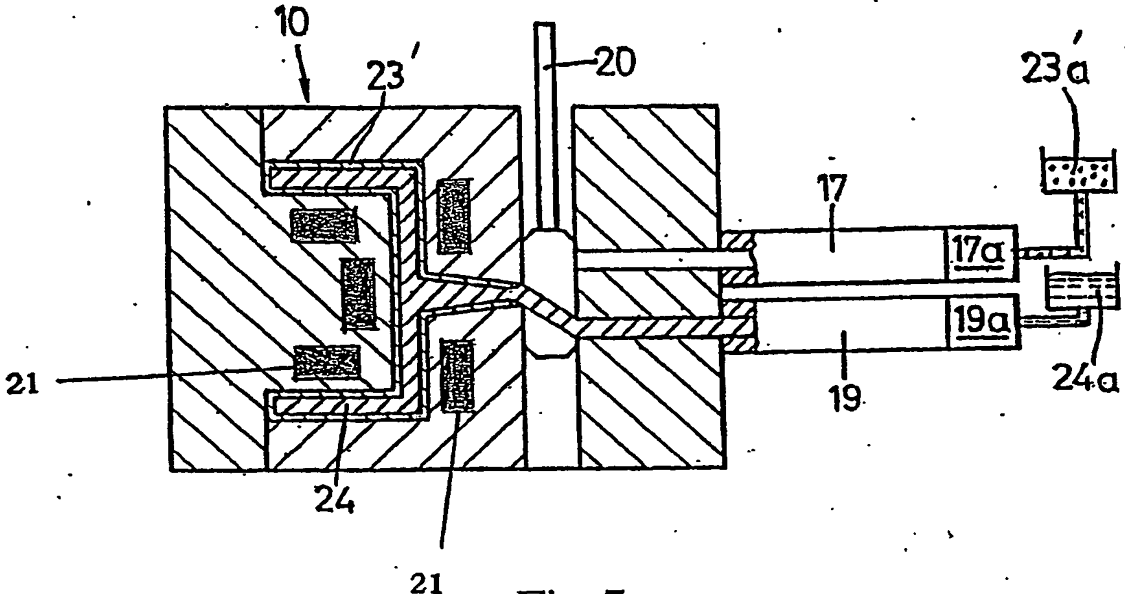
10
23'
20
23a'
17
17a
19a
21
24a
19
24
21

Fig. 7

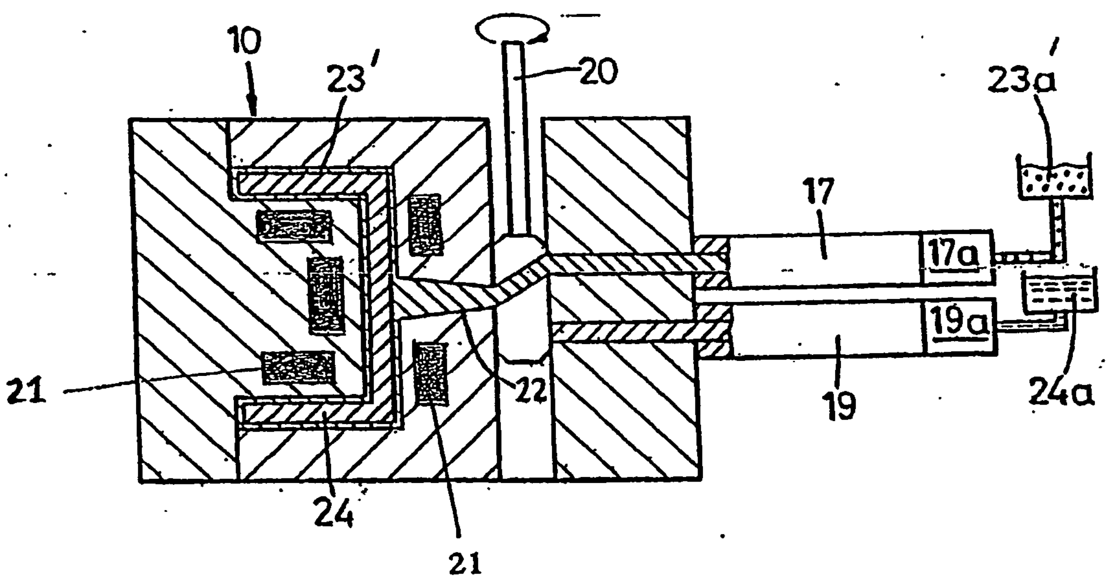
10
23'
20
23a'
17
17a
19a
21
22
24a
19
24
21

Fig. 8

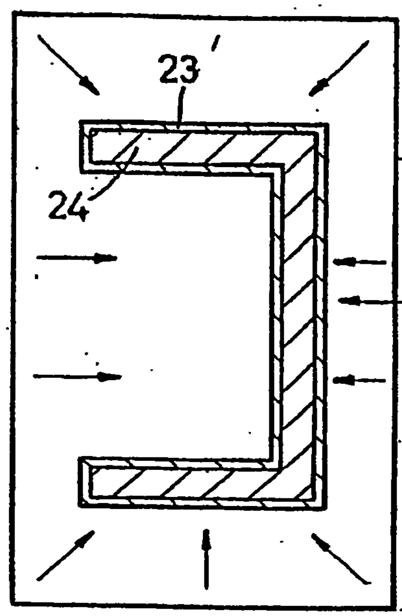

Fig. 9

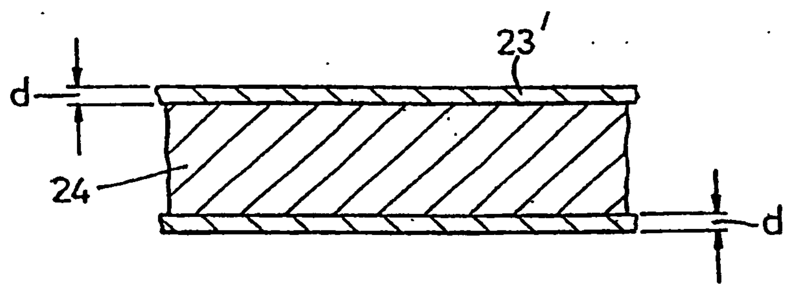

Fig. 10

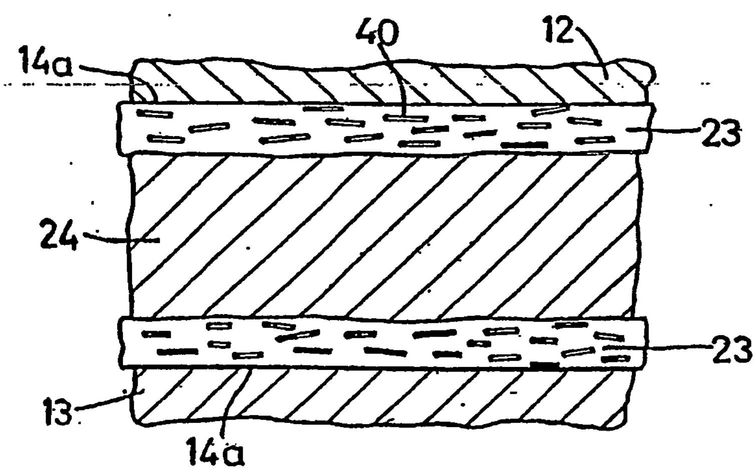

Fig. 11

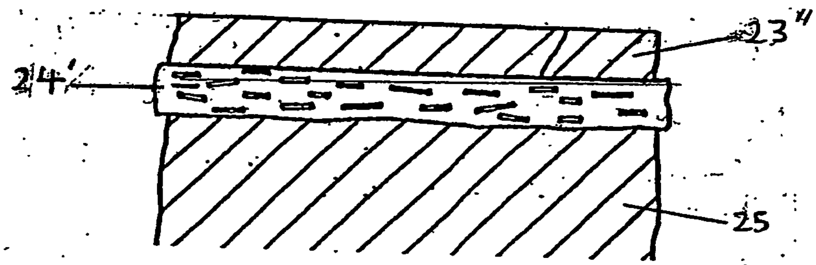

Fig. 12